Screening Apparatus

Background of the Invention

1. Field of the Invention

The present invention relates to screening apparatus for use at an overflow weir in a sewerage system and a method of manufacturing screening apparatus. More specifically, the screening apparatus is configured for use with a side weir of a sewerage channel.

2. Description of the Related Art

Sewerage channels carry a mixture of liquids and solids to treatment plants. During wet weather, some channels receive rain water and consequently their flow levels are raised. To manage increased flow rates, such channels are provided with overflow weirs which allow excess water to leave the sewerage system and enter a watercourse such as a river.

In order to prevent undesirable solids from leaving the sewerage channel by the overflow weir and entering a watercourse, it is known to provide a screen along the weir. Such a screen allows a flow of water over the weir but screens out solid matter which is maintained in the flow in the sewerage channel.

A screen in this situation can become blinded, i.e. blocked, by the solid matter in the mixture. Consequently, it is known to provide screens in the form of a horizontal continuous moving band which move past a cleaning device to prevent blinding. During high flow level conditions, the lower surfaces of the screen provide the filtering function while the upper surface is intended to operate above the water level such that it may be cleaned by the brush.

Such screens are limited in their effectiveness to allow water to flow

freely over the weir. In addition, during extreme conditions, the brush may become submerged which leads to ineffective cleaning and the screen becoming rapidly blinded. Consequently, the screen becomes completely ineffective until the extreme conditions have subsided.

US Patent 4,242,205 to Hirs discloses a continuous belt filter having a horizontal portion and a portion at an upward angle to the horizontal. The top of the angled portion is positioned such that in normal use it is not submerged in the liquid to be filtered. The non-submerged portion is provided with a water or air jet for cleaning. This design is not believed to be suitable for use in a sewerage system.

Accordingly, it is an object of the present invention to provide a screen apparatus for use at an overflow weir in a sewerage system that can be cleaned effectively even when water is flowing over the weir.

Brief Summary of the Invention

According to a first aspect of the present invention, there is provided screening apparatus for use at an overflow weir in a sewerage system, comprising a continuous moving screen band and a band cleaning mechanism comprising a cleaning device made of a solid but flexible material, wherein a first portion of said screen band is configured to move along said weir towards one end of said weir, a second portion of said screen band is configured to move along said weir towards the opposite end of said weir, a steeper portion of said screen band extends to an elevated position above said first and second portions, and said band cleaning mechanism is arranged to remove solid matter from the screen at said elevated position. It is preferred that the elevated position does not become submerged, even when water is flowing over the weir.

According to a second aspect of the present invention, there is provided a method of screening sewage at an overflow weir in a sewerage system, comprising the steps of: moving a continuous screen band around a guide means such that a first portion of said screen band moves along said weir towards one end of said weir, a second portion of said screen band moves along said weir towards the opposite end of said weir, and a steeper portion of said screen band extends to an elevated position above said first and second portions; and cleaning solid matter from the screen at said elevated position by means of a band cleaning mechanism comprising a cleaning device made of a solid but flexible material. It is preferred that the elevated position is located such that it does not become submerged even when water is flowing over the weir.

In a preferred embodiment the cleaning mechanism comprises a rotating cleaning device. An example of such a device is a rotating cylinder, longitudinally provided with strips of a flexible material, for example polyethylene. The strips nearest to the band engage the band in a touching relationship. When the cylinder is rotated, the flexible strips clean the band in a combination of scraping and flicking actions. As the cleaning device is in contact with a portion of the band that does not become submerged, the cleaning action of the flexible strips is not impeded by being immersed in water.

In a particularly preferred embodiment the cleaning mechanism comprises a rotating brush. It is believed that the flicking action is an important part of the cleaning action of brushes. Since the bristles do not become submerged this flicking action is not impeded, allowing the brushes to keep their cleaning efficiency even when water flows over the weir.

The material of the bristles is selected to provide a good combination of strength, durability, and flexibility. Suitable bristle materials include nylon, polypropylene, and polyethylene. Other materials may be selected, as will be apparent to those skilled in the art.

Brief Description of the Several Views of the Drawings

Figure 1 shows a screening apparatus **101**, partly submerged in sewage **102**;

Figure 2 shows the screening apparatus **101** of *Figure 1* without the sewage **102** in chamber **103**;

Figure 3 shows the screening apparatus **101** with the weir **301** indicated by dashed lines;

Figure 4 shows the screen band **201** removed from the apparatus **101**;

Figure 5A shows a cross sectional view of screen panels **401** and **402**, and

Figure 5B shows a top view of screen panels **401** and **402**;

Figure 6 shows the blanking plate **109** and associated chain guide;

Figure 7 shows a cross-sectional view of the screening apparatus **101**, and the weir **301**, through screening panel **402**;

Figure 8 shows a schematic representation of the screen band **201**, the blanking plate **109** and the cleaning brush **608**;

Figure 9 shows an alternative screening apparatus **901** embodying the present invention; and

Figure 10 shows a cross-sectional view of the screening apparatus **901**, which illustrates the function of the box structure **904**.

Written Description of the Best Mode for Carrying Out the Invention

Figure 1

A screening apparatus **101** is shown partly submerged in sewage **102** in a continuation chamber **103** in *Figure 1*. The level of sewage **102** illustrated in *Figure 1* is a typically high level that is reached when the sewerage system has received large amounts of rain water.

The sewage **102** is a liquid and solid mixture which flows into the chamber **103** from a sewer pipe **104**. At least a portion of the sewage **102** exits the chamber **103** via sewer pipe **105** and may continue flowing to other parts of the sewerage system leading to a sewage treatment plant.

During periods when flow rates are low, all sewage entering via pipe **104** will subsequently exit via sewer pipe **105**.

A concrete wall **106** of the chamber **103** separates said chamber from an overflow chamber **107**. A section of the wall **106** is of a lower height than the sections either side of it, and the lower section defines a weir. During periods when flow rates along the sewer are high, the level in the chamber **103** becomes correspondingly high. (As illustrated in *Figure 1*.) To assist the lowering of the high water levels, excess water is allowed to flow from chamber **103**, over the weir and into overflow chamber **107**. The excess water then flows from chamber **107** to a watercourse, such as a river, or a storm tank, via pipe **108**.

A blanking plate **109**, which forms a part of the screening apparatus **101** is rigidly attached to the concrete wall **106**. The blanking plate **109** closes off the gap between the two higher portions of the wall **106**, such that in order to pass over the weir, water from the sewage **102** must first pass through submerged screening panels of the apparatus **101**.

It may be noted that the upper edge **110** of the blanking panel **109** is

at the same height as the top of the wall **106**. In extreme conditions when the sewage level in chamber **103** continues to rise above that illustrated in *Figure 1*, and reaches the upper edge **110** it will then spill over said edge into the overflow chamber. Therefore, the upper edge **110** defines an emergency overflow level. It may also be noted that a motor housing **111** which provides a housing for drive machinery of the apparatus **101** is located above the emergency overflow level, and therefore remains above water even during extremely high flow levels.

Figure 2

The screening apparatus **101** of *Figure 1* is shown in *Figure 2*, without the sewage **102** in chamber **103**. The screening apparatus **101** has a continuous screen band **201** comprising a plurality (typically 30 to 40) of screening panels hingedly connected together.

One edge **203** of the screen band **201** is mounted within a first guide, which also provides a seal preventing the passage of sewage around the edge of the band. The opposite edge is located within a similar second guide having similar sealing means. The first guide is mounted on the blanking plate **109**, while the second guide is mounted on a side plate **204**, itself being rigidly supported by the blanking plate **109**.

The screen band **201** forms a continuous loop having a horizontal branch **205** extending along the weir and a second branch **206** rising at an angle of 45 degrees to the horizontal.

The continuous screen band **201** is driven around its guides by means of a pair of sprockets located at its upper end. Thus the side panel **204** supports a bearing housing **207** which contains the bearings of the sprocket axle. The sprockets, and hence the screen band, are driven by an electric motor located within the housing **111**.

A brush is located inside a cover plate **208** at the upper end of the screen band. The brush has a cylindrical profile and is driven in a rotating manner by a second electric motor located within housing **111**. In operation, the brush removes solid material from the upper end of the screen band.

Figure 3

The screening apparatus **101** is shown in *Figure 3* with the weir **301** indicated by dashed lines.

The overflow weir **301** has a shaped profile to facilitate the passage of water from the screening apparatus **101** into the overflow chamber **107**.

Generally, during periods of low flow levels, the sewage level in the chamber **103** is below the apparatus **101**. No screening is required and the apparatus is powered down. However, during high flow levels, i.e. when the sewage level in the chamber **103** is above the weir **301**, water passes through the screen panels of the band **201** and over the weir **301**. A sewage level sensor, (not shown) for example an ultrasonic level probe, is located above the chamber **103**. When the sewage level reaches the height of the top of the weir, signals from the level sensor are used to activate the motors driving the screen band and the rotary brush. Consequently, the panels of the screen band **101** are moved past the brush which sweeps solid matter adhered to the screen band back into the sewage stream in chamber **103**.

In an alternative embodiment, the signals from the sewage level sensor are used to activate the motors driving the screen and brush when the sewage level rises above the lowest screen panels of the screen band **201**. Thus the screen band is cleaned during the period when the sewage level rises to the weir height.

Figure 4

The screen band **201** is shown removed from the apparatus **101** in *Figure 4*. The screen band comprises 32 screen panels, such a panels **401** and **402**. Each screen panel is rigidly attached to a respective link in a continuous loop chain **403** which runs along one edge **404** of the screen band **201**, and to a respective link in a second similar chain on the opposing edge **203**. When assembled in the apparatus **101**, the chain **403** runs along the guide on the side panel **204** while the other chain runs along the guide on blanking panel **109**.

The screen panels each have a curved screening section extending between a pair of flat end plates, such as end plates **405** and **406** of screen panel **402**, which extend perpendicularly to the curved screening section. The outer surfaces of the end plates provide a sealing surface in the assembled apparatus.

Figures 5A and 5B

A top view of screen panels **401** and **402** is shown in *Figure 5B*, while a cross sectional view of said panels, along line VV, is shown in *Figure 5A*.

Each of the chains **403** and **503** are similar to bicycle chains. Therefore, each link comprises a pair of parallel plates pivotally connected to adjacent links, and the links alternate between narrowly spaced plates, such as plates **502A** and **502B** of link **501**, and widely spaced plates, such as plates **504A** and **504B** of link **506**. A pivot pin, such as pin **507** pivotally connects adjacent links, and a rotatable spacer, such as spacer **508**, located on the pivot pin separates the narrowly spaced plates. The spacer **508** is a cylindrically shaped piece of metal which is configured to be acted upon by a respective one of two drive sprockets (illustrated in *Figure 6*).

The inner plate of each link is attached to the respective end plate by

a pair of bolts. Thus, for example, the inner plate **504A** of chain link **506** is attached to end plate **406** by two bolts **509**.

The shape of the end plates is most clearly shown in *Figure 5A*. Each plate is similarly shaped, having a convex circular front edge and a concave circular rear edge of the same radius. Thus, adjacent screen panels are able to pivot about each other while the respective end plates remain in abutting relationship.

The curved screening section of each panel, such as section **510** of panel **402**, defines an array of 6mm (six millimetre) diameter circular apertures. It is these aperture arrays which allow the passage of water from the chamber **103**, over the overflow weir, into overflow chamber **107**, while preventing larger particles of solid material suspended in the sewage **102** from entering chamber **107**.

In the present embodiment, the screen band **201** is manufactured from stainless steel components. However, in an alternative embodiment, the curved sections defining the screening apertures are made from a plastics material.

Figure 6

The blanking plate **109** and associated guide is shown in *Figure 6*. The guide comprises several parts, namely: an outer guide element **601**; an inner bend guide **602**, and upper and lower inner guide rails **603** and **604** respectively. The guide rails **603** and **604** are fabricated from stainless steel, while the outer guide element and inner bend guide are machined from polyethylene.

The outer guide element **601** is separated from the inner bend guide **602** and the inner guide rails **603** and **604** by a gap **605** configured to receive the chain **503**. (The location of chain **503** is indicated by dashed line **610**.)

When the apparatus **101** is assembled, with the chain **503** in the gap **605**, the outer surfaces of the end plates, such as end plate **405,** are in close proximity to the outer guide element **601**, and, therefore, said end plates in co-operation with said outer guide element provide a sealing means.

An elongated aperture **606** is cut in the blanking plate **109** inside the path of the screen band defined by the gap **605**. In use, the aperture **606** extends along a large proportion of the weir, and provides a water outlet from the apparatus **101** to the weir **301**.

One of the two chain drive sprockets **607**, and the screen band cleaning brush **608** are also illustrated in *Figure 6*. The screen band is driven by the sprockets **607** located at its highest end, and the cleaning brush cleans a portion of the band currently passing around said sprockets.

Figure 7

A cross-sectional view of the screening apparatus **101**, and the weir **301**, through screening panel **402** is shown in *Figure 7*. As described above, the chain **503**, which supports screening panels of screen band **201**, is located between an outer guide element **601** and inner guide rails **603** and **604**. The close proximity of end plates, such as end plate **405**, and the outer guide element **601** provide a seal between the screen band **201** and the blanking plate **109**.

Similar outer guide element **701**, and inner guide rails **703** and **704**, mounted to side plate **204**, provide a guide for the chain **403**.

A number of centre braces **710** rigidly connects the side plate **204** to the blanking plate **109**.

In this embodiment, the weir is constructed by forming a portion **711** of wall **106** with reduced height, below the level of the normal weir setting. The height of the weir **301** is then brought up to the level of the weir setting **712**

by a profiled member **713**. The profiled member **713** is formed from stainless steel and is rigidly attached to the top of the wall portion **711**. The profiled member **713** has a surface which curves upwards away from the screening apparatus **101**, such that the weir **301** is provided with an upper edge of reduced width. Consequently, a void is provided adjacent to the aperture **606** in blanking plate **109** which facilitates the flow of water from the apparatus and out over the weir.

Figure 8

A schematic representation of the screen band **201**, the blanking plate **109** and the cleaning brush **608** is shown in *Figure 8*. During operation, the screen band **201** moves continuously around the circuit formed by the guides and the sprockets **607** of apparatus **101**. However, at any moment in time, the screen band has a first horizontal portion **801** which moves along the weir **301** towards one end of said weir in direction of arrow **802**. Thus, the lower horizontal portion **801** moves in the general direction of sewage flow through chamber **103**. The screen also has a second horizontal portion **803** which moves along the weir **301** towards the opposite end of said weir in direction of arrow **804**. A third portion **805** of the screen band **201** extends upwards from the lower horizontal portion **801** to an elevated position **806** where the cleaning brush **608** acts upon said screen band to remove unwanted attached solid matter. The brush is driven in direction of arrow **807** such that the solid matter tends to get brushed off, back into the sewage, as indicated by arrow **808**.

In the present embodiment a fourth portion **809** of the screen band **201** extends upwards from the second portion **803** to the elevated position, substantially parallel to the third portion.

In alternative embodiments the third and fourth portions may not be

parallel, and in one particular embodiment, the third portion rises substantially vertically.

To provide a robust band and guide system, while keeping the dimensions of the apparatus within tolerable limits, the third portion **805** extends at an angle of between 30 and 60 degrees to the horizontal, and an angle of 40 to 50 degrees is preferred.

In use, when the sewage level in chamber **103** reaches the weir height, indicated by dashed line **821**, the screening apparatus **101** starts to perform its screening function, and the driving motors housed within housing **111** are activated. When the flow level gets above the level of the upper horizontal portion **803**, said portion also filters debris from the sewage and allows water to flow through to aperture **606** and weir **301**.

It may be noted that additional screening, to that provided by the first and second horizontal portions **801** and **803**, is provided by submerged parts of the angled third and fourth portions **805** and **809**.

When the sewage level rises to a height above the emergency overflow **110**, a proportion of the flow to the weir will be over the emergency overflow but a major proportion of flow will continue to be through the screen band **201** and aperture **606**. Thus in extreme conditions, when the screening apparatus is unable to keep the sewage level below the emergency overflow level, it can still operate at its full capacity. This is because the elevated position **806** where the brush acts is still above the sewage level.

As a consequence of this, when the level of sewage drops below the emergency overflow level, the apparatus **101** continues to operate normally to further reduce the level.

Figure 9

An alternative screening apparatus **901** embodying the present

invention is shown in *Figure 9*. The apparatus **901** is substantially the same as screening apparatus **101** of *Figure 1* in that: it has a continuous moving screen band **902** comprising a plurality of connected screening panels; the screen band **902** has an upper horizontal portion **903** which moves along the weir from right to left, and a lower horizontal portion moving along the weir from left to right; and a third portion extends upwards from the lower horizontal portion to an elevated position where a brush cleaning mechanism, located under cover plate **904**, removes solid debris from the screen band **902**.

The arrangement of *Figure 9* differs from that of *Figure 1* in that the blanking plate has been replaced by a box structure **904**. The screening apparatus **901** is located on a front panel **905** of the box structure **904**, with the front panel being attached to the wall **106** by two side panels **906** and a bottom panel (shown in *Figure 10*). The front, side and bottom panels of the box structure **904** are leak-proof and are sealed to the wall **106** such that sewage cannot escape from chamber **103** to overflow chamber **107** without passing through the screening apparatus **901**. The box structure **904** provides a space between the screening apparatus **901** and the weir **910**, to allow water to escape from said apparatus and pass upwards over the weir **910**. Consequently, weir **910** has a conventional structure, being completely formed in concrete.

Figure 10

The function of the box structure **904** is illustrated by the cross-sectional view of the screening apparatus **901** in *Figure 10*. The bottom panel **1001** and side panels **906** of box structure **904** support the front panel **905** such that it is parallel to and spaced from the wall **106**. Consequently, a void is produced between the lower portion of the side panel **905** and the weir

910, so that water leaving the screening apparatus **902** via aperture **1002** passes through the void produced by the box structure **906** and over the weir **910**.

It should be noted that the relative height of the weir **910** and the upper horizontal portion **903** of the screen band **902** is similar to that of the first embodiment illustrated in *Figure 7*. Thus, like the screening apparatus **101**, screening apparatus **901** screens solid matter from the sewage using the upper horizontal portion **903** as well as the lower horizontal portion **1003**.

A number of cantilever support posts **1005** arranged between a lower part of the screening apparatus **901** and the wall **106** provide additional support for said apparatus.